Food Security by 2050 : Insights from the Agrimonde Project

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Purpose

The brief describes the methodology and conclusions of a foresight project called Agrimonde. Between 2006 and 2008, this project gathered a panel of French experts who built two contrasting scenarios of the world's food and agricultural systems by 2050: Agrimonde GO, a business-as-usual scenario used as a reference point, and Agrimonde 1, a rupture scenario exploring a world that has been able to implement sustainable food production and consumption.

Food Security Issues Back at the Forefront

The future of global agricultural and food systems is today at the heart of numerous intertwining debates. They stem from the increasingly widespread certainty that the continuation of current trends in food consumption and production is unsustainable and that radical changes in behaviour, policies and technologies are necessary (MA 2005, World Bank 2008, IAASTD 2009). Three trends now appear inevitable: 1) the (still) fast growth of the world's population, 2) climate change, and 3) the increasing scarcity and rising prices of fossil fuels. In view of these trends, several studies have warned of a possible stagnation of yields in various crops (IAASTD 2009), and the Millennium Ecosystem Assessment (MA) has highlighted the ***deterioration of ecosystems*** and the consequent threats to the multiple services that they render to humanity (MA 2005). Besides structural trends, the threat of ***food riots***, re-occurring as a result of the current price volatility and the possible impacts of competition between food and biofuel production, have brought food security issues to the forefront.

Undernourishment figures confirm the seriousness of the situation. Indeed, after declining at the end of the 1970s, the number of undernourished people started to rise again in the mid-1990s and has now reached approximately 1 billion (FAO 2010).

The issue being raised again is that of a possible structural tension between the potential growth of food production and the increase in the demand for agricultural products, driven by economic and demographic growth, changing diets and the growing need for alternative sources of energy.

The Agrimonde Project

Between 2006 and 2008, responding to an initiative of CIRAD and INRA, the two main French agricultural research institutions, a panel of French experts developed a project called Agrimonde with the goal to build and analyse contrasting scenarios of the world's food and agricultural systems by 2050. The project's objectives were threefold: 1) to anticipate the key issues research will have to address; 2) to initiate a process of debates and appropriation of the topics on a national scale; 3) to promote the participation of French experts in international debates on food security issues.

Qualitative Storylines and Quantitative Modelling Used in an Interactive Way

Drivers for the evolution of food and agriculture are extremely diverse and numerous. To cope with this complexity, we based scenario building on complementary quantitative modelling and qualitative analyses. Storylines about the main drivers of change guided us in making sets of quantitative assumptions. These assumptions were used to simulate resource-use balances of food biomass at global and regional levels, which in turn enriched the content of each storyline through efforts to enhance coherence. This iterative process eventually enabled us to develop comprehensive quantitative and qualitative scenarios.

Quantification was performed using the quantitative tool ***Agribiom***, thanks to which all agricultural food productions, consumptions and trade can be evaluated using one single measuring unit, the kilocalorie. Calories are distinguished according to their origin: plant, animal (grazing and non-grazing) and aquatic. Agribiom comprises data covering four decades (1961-2003), enabling us to analyse past trends in the whole range of plant and animal productions and utilizations worldwide.

Quantitative assumptions on future biomass resources and uses were made at the regional level (Asia (ASIA), the Former Soviet Union (FSU), Latin America (LAM), Middle East/ North Africa (MENA), OECD, Sub-Saharan Africa (SSA)). The coherence of each set of quantitative assumptions was checked by assessing the balances between food biomass resources and their uses. There might be deficits in some regions, but resources should cover uses at global level.

Assumptions on ***regional biomass*** use in 2050 combines assumptions on ***human population*** and their diets. As for resources, assumptions were made at regional level concerning mainly: 1) land use, 2) cultivated land productivity measured in calorie per hectare, and 3) conversion of plant calories into animal calories.

To establish the values that these variables could take in 2050, we analysed 1) past trends, 2) the scientific literature dealing with each variable's determinants, and 3) scenarios built in the various studies dealing with food and agriculture. Only the conversion of plant into animal calories was simulated. The magnitude of the increase in animal food consumption is a clue to the planets' future capacity to feed its population since husbandry accounts for a substantial share of the use of plant calories. It was therefore important to precisely grasp ***calorie conversion***. Thus, unlike other scenario-building studies based on economic models, Agrimonde uses a simple quantitative model processing physical, not economic, data. It does not simulate the functioning of the main commodity markets. This shortcoming, however, is partly offset since Agribiom avoids the "black box" feature of complex modelling with a multitude of parameters and causality relationships.

The Agrimonde Scenarios

We chose to build two scenarios: a ***business-as-usual scenario called Agrimonde GO (AGO)***, inspired from the MA Global Orchestration scenario, and a ***rupture scenario called Agrimonde 1 (AG1)***. This scenario explores a world in 2050 that has been able to implement sustainable development through a drastic reduction of both undernourishment and excessive food intake, and a change of the technological paradigm towards ecological intensification. In keeping with the definition proposed by Conway (1998) or Griffon (2006), ecological intensification was defined as the diffusion of practices and technologies enabling agriculture to meet growing needs, to be a driving force of economic development and to preserve natural resources.

Two general principles were applied to the construction of the scenarios so as to facilitate their comparison. Firstly, in order to assess the capacity of each region to satisfy its own food needs in 2050, ***interregional trade*** was considered only as a way of clearing regional surpluses in some regions and of filling deficits in others. Secondly, we wanted each region to experience the same ***demographic pressure*** in both scenarios and to analyse the effects of demographic trends without them being masked by large migratory flows. Consequently, we chose for both scenarios the United Nations (UN) median projections of ***population growth*** (around 9 billion people worldwide in 2050 with a "normal" level of international migration).

For AGO and except for the demographic assumptions mentioned above, we used the quantitative assumptions made in the framework applied by the MA. A normative choice, based on an understanding of what a sustainable diet might be, prevailed in the elaboration of assumptions on food consumption in AG1. In AGO, economic growth boosts consumption in all regions whereas in AG1, the income-food consumption nexus is not the most determining one due to concerns for health, equity and the environment. Food availability in 2050 is assumed to equal 3,000 kcal/cap/day (500 of which of animal and aquatic origins) in all regions, which corresponds to the global average in 2000. An average availability of 3,000 kcal is also the figure that FAO considers sufficient to maintain the proportion of undernourished people at a relatively low level. This assumption nevertheless contrasts sharply with past trends, especially in Sub-Saharan Africa where food consumption is supposed to increase by 30% over 50 years and in the OECD countries where it is supposed to decrease by 25%.

AG1's assumptions pertaining to land areas were made on the basis of physical factors of soil availability and quality and compared with sustainability criteria (in particular the

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preservation of forest areas). Finally, the assumptions on yields were formulated by considering past trends and technological change that would make it possible to increase yield while preserving the ecosystems. Among factors taken into consideration, the anticipated impacts of climate change on land availability and yields were considered major determinants of the future production potentials. As a result, at the global level between 2000 and 2050, cultivated land increases much faster in AG1 with 12 million hectares of new cultivated land per year (taken for the most part on current pasture areas) against 7 million in AGO, and 4 million in the last four decades of the 20th century. In AGO, yields are the driving factor; they increase by 1.14% per year over 50 years, against 0.14% in AG1, and 2% per year between 1961 and 2000.

Feeding the Global Population in 2050 a Matter of Access Not Food Shortage

Five main lessons can be drawn from the Agrimonde's global-level scenario analysis (see Paillard et al. 2011 for further details, in particular at regional level).

Firstly, the global food production levels assumed in each scenario for 2050 satisfy the assumed levels of global food consumption. The ***planet's natural resources are sufficient to properly feed the global population in 2050***, which is approximately the year when the maximum global population is anticipated. Thus, just like today, the main challenge in terms of food security will not be a lack of production but will remain a problem of ***access to food*** by the poorest populations.

Secondly, the scenarios underline the crucial role of diets in the realisation of resource-use balances. On the one hand, in AGO, per capita total food availability increases by 20% between 2000 and 2050 and the share of animal products increases from 16 to 23%. On the other hand, in AG1, these indicators remain stable at global level. As a result, while the global need in plant calories (including plant food, feed, seeds, loss etc.) increases by 90% in AGO, it only increases by 35% in AG1. The ***convergence of diets and of consumption habits*** (growing consumption outside the home and of processed food, generating growing waste) towards the Western model would then have serious consequences not only from a health viewpoint (obesity and related diseases) but also for the preservation of ecosystems.

Thirdly, in both scenarios, the volume of net trade in food between regions necessary to meet regional food needs is much higher in 2050 than that observed in 2000. Three regions show structural shortages in both scenarios. Two of them, ASIA and MENA face a shortage in natural resources (water and land). In the third, SSA, the increase in food production is lower than population growth and the corresponding increase in food consumption. Thus ***trade regulations appear essential*** in order to 1) prevent net exporting countries from taking advantage of the structural food dependence that some regions face, 2) avoid competition that would be unsustainable for small local producers, and 3) guarantee that trade does not lead to an increase in the impacts of agriculture on the environment.

Fourthly, in AG1, yield gains, while fast in regions such as LAM or FSU, are very moderate at global level. Thus, even under the assumption that yields will increase relatively slowly, the planet can properly feed nine billion people in 2050. Consequently, ecological intensification, through the scaling up of ***local agro-ecology experiments***, appears to be an alternative option to the classical model of agricultural intensification, as recently pointed out by Olivier de Schutter, the UN Special Rapporteur on the Right to Food (de Schutter 2011).

As he emphasized, the main benefits of agro-ecology lie in the fact that it preserves natural resources and is accessible to smallholders (low input and capital intensity). This brings us to our ***fifth*** conclusion: the contribution of trade to the food security of regions with food shortages will only be possible if ***access to food*** in those regions is drastically enhanced through the development of local opportunities for wealth creation. And because in the most food insecure countries, these opportunities are mostly to be found in agriculture, investments in this sector in developing countries is the key to end undernourishment.

Agrimonde: a Landmark Study Provoking Controversies

Agrimonde has become a landmark foresight study (mostly among French experts and stakeholders). The AG1 and AGO scenarios are references, whether adopted or rejected, that contribute to structuring the debate on food security and more generally on the future of food and agricultural systems. This can be stressed through some of the main controversies provoked by the scenarios, which concern their sustainability and plausibility.

Tackling Environmental Issues

Environmental sustainability is not a feature of the AGO storyline since in this scenario economic growth is given priority over the preservation of the environment. Nevertheless, AG1 and AGO can be considered as two different strategies to meet the challenge of feeding a growing population in a sustainable way. On the one hand, AGO bets on substantial yield gains that would make it possible to spare land areas – reserves, corridors, forests, etc. – which then can be devoted to the preservation of ecosystems. On the other hand, AG1 chooses to expand cultivated areas and to use environment-friendly technologies to cultivate them at the accepted cost of lower yield gains. The conversion of land into cultivated

areas accelerates compared to past trends, particularly in regions with a large unexploited cultivation potential, such as SSA, LAM and FSU. Even though forests are spared, accelerated land conversion is not without impact on biodiversity and carbon storage. However, the sustainability assessment of AG1 cannot end here. For instance, it would be meaningless to measure its carbon footprint by simply multiplying converted land areas by the quantity of carbon that is currently emitted when pastures are converted into cultivated land. Ecological intensification actually strives toward a higher carbon storage capacity through innovations in farming systems and lower emissions through a reduction in nitrogen fertilizer use.

In AG1, ecological and productive functions of ecosystems are combined on the same territory (agroforestry is a good example of such a combination), which tends to blur the traditional frontier between productive areas and preserved nature areas. Thus, technological choices appear strongly linked to our choices of spatial organisation and complementary to the performance criteria that are applied to farming systems. In AG1, these criteria have to be designed to measure not only their food production performance but also their ability to maintain ecosystem services, which is not central to what is expected of agriculture in AGO.

Legacy of the Growth Paradigm

The plausibility of the Agrimonde scenarios and the feasibility of the transitions that they propose provide another interesting area of debate. AGO is a plausible scenario if trade liberalisation and technological progress are sufficient drivers of economic development. Moreover, it requires that we will be able to further increase yields through radical innovations, such as drought-resistant GM crops. The scale of the challenge is huge if we consider the very high level of yield already attained in regions such as ASIA and the OECD as well as the current health of many ecosystems and the consequences, over next decades, of climate change and fossil fuel rarefaction. AG1 rests heavily on the availability of arable land. Even though existing data tends to show large amounts of uncultivated arable land, more reliable data on land use, soil fertility and possible future impacts of climate change and urbanisation are needed to check the plausibility of land use assumptions in AG1. Moreover, the existence of large unexploited arable land areas does not necessarily imply that they will be available for food production. For instance, in regions where land tenure is customary, land conversion would have dramatic impacts on pastoralists whose food security depends heavily on their having access to rangeland. The competition between food and biofuel production is also likely to affect the amount of land that will be devoted to food production.

Diet Change in Rich Countries?

The radical shift in diets is certainly the most challenging feature of AG1. This scenario assumes a 25% drop in food consumption in OECD over 50 years, mainly through a decrease in animal product consumption. Likewise, it assumes that emerging countries will manage to rapidly curb the current trend towards diets higher in fat and meat. These very strong assumptions do not challenge the interest of this scenario since foresighting is not forecasting, and exploring ruptures in trends is one of the main purposes of scenario building. Besides, health and environmental concerns are prompting an increasing number of rich countries' consumers to modify their diets and limit food waste. It is therefore plausible, and in any case interesting, to consider the implications of a progression of such behavioural changes in rich countries. The question calls for a radically different answer when considering developing countries in which a significant share of people do not have access to sufficient food and lack proteins. The assumption that in coming decades, consumers will become concerned about the ecological footprint of their consumption behaviour does not seem plausible. However, nutrition transition in emerging countries is far more rapid than it was in Northern countries. It is therefore probable that the populations' awareness of the harmful effects of excessive calorie and fat intakes will also spread faster.

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